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TRAINING EFFECTIVENESS EVALUATION OF A PROTOTYPE WATER-SPRAY SMOKE ABATEMENT SYSTEM FOR FIRE FIGHTING TRAINING

MANNED SYSTEMS SCIENCES, INCORPORATED

PREPARED FOR

NAVAL TRAINING EQUIPMENT CENTER

NOVEMBER 1973

ABSTRACT

A study was performed to compare the training effectiveness of natural and smoke-abated simulated engine room fires through the use of objective measures of student performance augmented by student and instructor opinions.

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Results of the study showed that, during training, the group trained on natural fires performed better, but that their performance may have been due to factors other than training characteristics of the two types of fires. During criterion test fires, both groups performed comparably, indicating an equal transfer of training from both natural and smoke-abated training fires.

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FOREWORD

This report describes the results of a study performed for the Naval Training Equipment Center by Manned Systems Sciences, Inc., under contract N61339-72-C-0209.

The purpose of this study was to assess the relative effects of two training environments differing only in the presence or absence of smoke on the measured performance of selected groups of trainees. Considerable effort was devoted to the selection, matching, training and testing of the two groups to assure a meaningful and representative sample of Navy personnel.

Results indicate that trainee performance, measured in both clear and smoky test fires was equivalent, regardless of the environment in which the individual was trained.

Knox E. Miller

KNOX E. MILLER
Scientific Officer

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INTRODUCTION

Training Navy personnel to fight shipboard fires requires the use of training fires on shore. Typically, fuel oil is burned to create the training fires A by-product of the fires has been large amounts of highly visible smoke. The smoke is considered by some to be environmentally unsound.

The Naval Training Equipment Center has been involved for some time in the development of smoke abatement systems which may allow for adequate fire fighting training without the production of large amounts of smoke. One such system is the Prototype Water Spray Smoke Abatement System, which is described fully elsewhere (references 1 and 2).

In a simplified sense, an on-shore training fire is created by burning fuel oil on the surface of a water-filled bilge. The Prototype Water Spray Smoke Abatement System (WSS) uses nozzles which spray water horizontally across the fire at a height of several inches above the base of the flames. Results are the production of very small amounts of smoke and the creation of practically smokeless training fires.

A number of qualified Navy personnel have questioned the training effectiveness of "smokeless" training fires. Their questions have arisen from the fact that shipboard fires, by nature, produce smoke. These Navy personnel have reasoned that building a student's confidence in overcoming smoke, as well as overcoming fire, is a meaningful objective of fire fighting training. This raised the question of how fire fighting training school students perceived natural (smokey) and WSS-treated ("smokeless") fires.

Miller (reference 3) recently completed a study investigating how students perceive both types of fires. He concluded that WSS-treated fires "can be made essentially equivalent to natural fires insofar as the perceptions of the trainees most involved in the extinguishment of the flames are concerned." Miller further stated that his findings were qualified by circumstances surrounding the study. One of the qualifications was that the study was based solely upon results of a questionnaire survey. Objective measurements of student performance could not be obtained.

A primary goal of the present study was to capitalize on the results of Miller's study and a first-time opportunity to obtain objective measures of student performance during both natural and WSS-treated fires. This goal, in turn, guided the development of training effectiveness evaluation objectives regarding natural and WSS-treated fires.

SECTION II

OBJECTIVES AND CONSTRAINTS

CONTEXT

Training effectiveness evaluation objectives of the present study were influenced by characteristics of the various types of training fires which were candidates for use in the study.

Training in the extinguishment of fires involves three fundamental types of fire situations. One type is the open tank fire. A second type is the simulated aircraft fire. Both of these fire types occur in open areas. Consequently, smoke poses little or no problem in the execution of extinguishment procedures.

The third type of training fire involves enclosed structures. Students are required to enter the structures to extinguish the fires. The abatement of smoke in enclosed structures could possibly alter the effectiveness of training. Accordingly, fire fighting training tasks involving an enclosed structure were selected for the study. Specifically, simulated engine room fires were selected. The selection also was governed by the fact that the engine room simulator at the Fleet Training Center, Fire Fighting School, Norfolk, Virginia was equipped with prototype WSS smoke abatement equipment.

EVALUATION OBJECTIVES

The overall training evaluation objective of the present study was:

> To compare the training effectiveness of natural and WSS-treated simulated engine room fires through the use of objective measures of student performance augmented by student and instructor opinions regarding the two types of fires.

The overall training evaluation objective provided the basis for the development of seven specific research objectives:

- Develop and use objective measurements of student performance.

- Develop and use devices for measuring student and instructor opinions toward the two types of fires.

- Develop and implement practical experimental designs and procedures for evaluating student performance during the extinguishment of either natural or

WSS-treated training fires and during the extinguishment of both natural and WSS-treated criterion test fires.

Compare student performance during training on either natural or WSS-treated fires.

Compare student performance and transfer of training during the extinguishment of both natural and WSS-treated criterion test fires.

Compare student opinions toward the two types of simulated engine room training fires.

Compare instructor opinions toward the two types of fires, both for the engine room simulator and for other types of training fires.

Accomplishment of all study objectives was achieved within the context of several training situation constraints which are discussed below.

CONSTRAINTS

Data were collected solely during the extinguishment of simulated engine room fires at the Fleet Training Center, Fire Fighting School, Norfolk, Virginia. Direct generalization of results of this study to other enclosed structure fire settings at this or other schools, to open tank and simulated aircraft fires, or to the training impacts of other means of smoke abatement, should be undertaken only with considerable caution.

A basic constraint underlying this study was the assumption that training procedures and simulation equipment presently used are successful in achieving desired training goals, thus providing a benchmark against which the effectiveness of WSS-treated training fires could be measured.

The importance of the above assumption is underscored by the fact that the present training situation is, for many reasons including safety, cost, convenience and pedagogical efficiency, an artificial and simplified representation of the real shipboard fire fighting problem. Equipment, procedures and materials used to extinguish simulated engine room training fires only vaguely resemble those which would be used to extinguish a real shipboard engine room fire. For example, neither students nor instructors wear oxygen breathing apparatus. Students enter the engine room simulator through three doors situated just above the base of the flames, rather than through overhead hatches. Water, rather than foam or light water, is used to extinguish the simulated engine room training fires. Finally, simulated engine room fires cannot be allowed to build to shipboard fire intensities because they

cannot then be extinguished with the materials and procedures used for training.

Accordingly, the primary basis on which the effectiveness of the WSS-treated training fire can be judged is with respect to the degree to which it can be used to provide training which is essentially equivalent to that which can be achieved using natural fires in the simulated engine room. Both the overall training evaluation objective and the seven research objectives must be interpreted in this context.

SECTION III

METHOD

SUMMARY

To allow for accomplishment of all study objectives, normal training was suspended at the Fire Fighting School for two one-week periods during October, 1972. Two independent groups, each consisting of 27 students, were trained and tested during two separate one-week periods. One group extinguished three natural training fires, one natural criterion test fire, and one WSS-treated criterion test fire. The second group extinguished three WSS-treated training fires, one natural criterion test fire and one WSS-treated test fire. All fires involved the simulated engine room structure. At the conclusion of each training fire and each test fire, instructors completed a detailed student performance checklist. At the conclusion of their training and testing, each group of students completed questionnaires and rating scales. At the conclusion of all training and testing, the instructors completed questionnaires and rating scales. All data were summarized and statistically analyzed as appropriate.

STUDENTS

Two independent groups, each consisting of 27 students, were trained and tested during the study. All subjects were enlisted men who were either rated or designated strikers. As shown in table 1, the two groups were well matched in terms of background experience.

During the study, students filled only the nozzleman positions on each active fire hose. Students did not man backup hoses or serve as hose handlers.

INSTRUCTORS

Six instructors were selected by the Fire Fighting School to perform all instruction and student evaluation tasks during the study. For each fire, one instructor was assigned to each student. Each instructor executed instructional tasks which are standard practice at the school for the engine room simulator. As such, each instructor briefed his assigned student prior to each fire, entered each fire with his assigned student to issue instructions, and observed the student's performance.

All hose handling tasks were executed by other Fire Fighting School instructors and Damage Control School instructors. One backup hose was in position at each door of the simulator throughout each training fire.

TABLE 1. SUMMARY OF STUDENT GROUPS

Personnel Data Categories	Group Trained on Natural Fires	Group Trained on WSS-Treated Fires
Job Specialty Area		
Administration and Supply	6	6
Deck and Weaponry	7	9
Engineering	11	10
Other	3	2
Years in Service		
Range	4 Mos. to 18 Yrs.	6 Mos. to 20 Yrs.
Average	3 Yrs., 9 Mos.	3 Yrs., 5 Mos.
Prior Fire Fighting Training		
Recruit	24	26
Advanced	7	5
Refresher	5	3
Aircraft	1	0
Team	1	3
Other	1	2
None	2	1
Fire Fighting Experience		
Shipboard Fires	3	1
Fires on Shore	2	4
Fire Fighting Training		
Within Past 6 Months	5	6

The use of instructors as hose handlers represented the only departure from standard procedures normally used at the school during the extinguishment of training fires in the engine room simulator. During normal training, other students serve as hose handlers.

Team coordination was improved by the instructors. Each active hose team consisted of a nozzleman (student) and seven hose handlers (instructors). Execution of extinguishment procedures required the coordinated team effort of eight individuals plus the evaluation instructor for each of three active hoses. The use of instructors as hose handlers virtually eliminated typical problems associated with integrated team efforts. Several instructors also felt that students might have

tended to act more aggressively, knowing that there were at least eight instructors with them and backing them up during the fires.

ENGINE ROOM SIMULATOR

All training and test fires occurred in the engine room simulator. Internal dimensions of the simulator are approximately 26 by 32 feet. The bottom of the simulator contains a bilge filled with water over which measured amounts of diezel fuel and gasoline were automatically dispensed and ignited to create the fires. Six WSS system water spray nozzles extended just above the bilge water line. For natural fires, the WSS system was not activated. For WSS-treated fires, the WSS system was activated shortly after ignition of the fires, and sprayed water horizontally just above the base of the flames. Students and instructors walked on catwalks situated approximately 18 inches above the bilge water line. All catwalks had guard rails. Two large metal boxes located in the port half of the simulator represented condensors. Students and instructors entered the simulator through forward, starboard and aft doors.

PERFORMANCE MEASUREMENT

Standardized objective measures of student performance were obtained through the use of a detailed student performance checklist. Performance checklists were completed by instructors immediately following each fire. An example of the checklist is shown in Appendix A.

The performance checklist was developed from fire fighting task requirements which were identified through conferences with Fire Fighting School instructors. Twelve student fire fighting tasks were identified in the sequence in which they are performed. Based upon additional instructor conferences, all possible student errors were identified for each of the 12 tasks. The performance checklist was then designed to allow instructors simply to place check marks by the errors which the students made on each task during each fire. Instructors also could check the degree of criticality of each student error.

An overall seven-point student rating scale was included as the last item in the checklist. Using the scale, instructors assigned an overall performance evaluation score to each student following each fire.

OPINION MEASUREMENT

Separate questionnaires were developed for students and instructors. Examples of the student and instructor questionnaires are shown in Appendices B and C respectively.

Semantic differential rating scales were administered to both students and instructors. The semantic differential scales consisted of 17 pairs of words. Each word-pair consisted of a descriptive term and its opposite (e.g., effective - ineffective). Each word-pair was separated by a seven point rating scale. Instructors and students placed X's along the rating scales to reflect the strength of their opinions regarding the training value of natural fires and the WSS-treated fires. An example of the semantic differential rating scales is shown in Appendix D.

Students completed their questionnaires and rating scales after they had completed all training and criterion test fires. Instructors completed their questionnaires and rating scales at the conclusion of all training and criterion test fires.

EXPERIMENTAL DESIGN - TRAINING FIRES

The following precautions were taken to ensure that all potentially systematic biases were eliminated or minimized during the collection of student performance data throughout training.

An independent groups experimental design was used. The first group of 27 students extinguished three WSS-treated training fires during the first three days of the first one-week period. The second group of 27 students extinguished three natural training fires during the first three days of the second one-week period.

In each group, the 27 students were randomly divided into three subgroups of nine students each. The first subgroup extinguished three training fires on Monday, the second subgroup on Tuesday, and the third subgroup on Wednesday.

Nine training fires were burned each day. During the course of the nine fires, each student fought three fires, one by entry through each of the three simulator doors.

Three students and three evaluation instructors were involved in the extinguishment of each training fire. One student-instructor team entered the simulator through the forward door, the second team through the starboard door, and the third team through the aft door. This was the normal training procedure for the engine room simulator.

Assignment of instructors and students to the doors through which the simulator was entered was carefully controlled to ensure that the following precautionary objectives were achieved:

Each instructor was assigned to each door an equal number of times.

Each student extinguished his three engine room fires by entering once through each of the three doors.

The number of times that any student was paired with the same instructor was minimized.

To reduce student fatigue, each student rested for two fires after having fought a training fire. To reduce instructor fatigue and allow time for completion of the student performance checklists, each instructor rested for one fire after having instructed in a training fire. During each rest period, each instructor independently completed a student performance checklist to evaluate the student whom he had just completed instructing.

EXPERIMENTAL DESIGN - CRITERION TEST FIRES

The following precautions were taken to ensure that all potentially systematic biases were eliminated during the collection of student performance data during the natural and WSS-treated criterion test fires.

A balanced groups experimental design was used. With this design, students were tested on Thursday or Friday of the week in which they had been trained. The following factors characterized the experimental design:

Ten criterion test fires were burned on Thursday of each week; eitht criterion test fires were burned on Friday of each week.

Half of the fires on each day were natural; the remaining half were WSS-treated. Natural and WSS-treated fires were burned in an alternating sequence on each day.

Fifteen students were tested on Thursdays; the remaining 12 were tested on Fridays.

The amount of time having lapsed since training was equalized in each test group. Of the 15 students tested each Thursday, 5 had been trained on Monday, 5 on Tuesday and 5 on Wednesday. Similarly, of the 12 students tested each Friday, 4 had been trained on Monday, 4 on Tuesday and 4 on Wednesday.

On their designated test day, each student extinguished one natural fire and one WSS-treated fire. On Thursday, 8 students extinguished a WSS-treated criterion test fire first and a natural fire second. The remaining 7 students extinguished the two types of fires in the reverse order. On Fridays, 6 students extinguished a WSS-treated fire first and a natural fire second.

The remaining six students extinguished the two types of fires in the reverse order.

Each student entered the simulator through a different door on each of his two test fires. Over the course of the tests, each door was entered an equal number of times by all students for each type of fire.

Over the course of the tests, each instructor was assigned to each door an equal number of times.

No student was ever matched with the same instructor for his two test fires.

Over the course of the tests, each instructor evaluated the same number of students in each type of fire.

As with the training fires, three students and three evaluation instructors were involved in the extinguishment of each criterion test fire. Each student-instructor team entered the simulator through a different door.

To reduce student fatigue and allow for systematic implementation of the complex experimental design, each student rested for three fires after having fought a criterion test fire. Each instructor rested for one fire after having participated in a criterion test fire. During each rest period, each instructor independintly completed a student performance checklist to evaluate the student with whom he had just entered the fire.

DATA TREATMENT AND ANALYSIS

Error data were summarized from the performance checklists for each student and each fire. The 12 student fire fighting tasks were clustered into three phases: preparation phase (tasks 1 through 4), extinguishment phase (tasks 5 through 10), and post-extinguishment phase (tasks 11 and 12). The total number of errors made by each student during each fire were determined for each phase. Separate statistical analyses were completed using the error data for each phase of the training fires and the criterion test fires.

Separate determinations were made of the number of students in each group who showed error-free performance during each phase of each fire. These values were converted to percentages for statistical analysis.

Instructor ratings of overall student performance were summarized for each group during each training and criterion test fire. Median ratings were determined and tested statistically.

Median ratings were determined from the semantic differential rating scale data. Separate statistical analyses of these data were completed for student ratings and instructor ratings.

Student and instructor questionnaire responses were separately tabulated and summarized. No statistical analyses of questionnaire data were performed.

Nonparametric statistics were used extensively because of inherent scale characteristics of some of the data and the nature of the frequency distributions of most of the data. The Wilcoxon Matched-Pairs Signed-Ranks Test (reference 4, pp. 75 - 83) was used for the comparison of different scores generated by the same student group. The Mann-Whitney U-Test (reference 4, pp. 116 - 127) was used for making statistical comparisons between the two student groups. Comparisons between percentages were made using the method recommended by Blommers and Lindquist (reference 5, pp. 319 - 320).

The results of all analyses are presented in Section IV.

SECTION IV

RESULTS

SUMMARY

Total numbers of student errors made during each phase of each training fire and each criterion test fire were determined and statistically analyzed. Separate analyses were completed for percentages of students exhibiting error-free performance during each phase of each fire. Instructor ratings of overall student performance were analyzed for each fire. Student and instructor questionnaire responses also were analyzed. Trends in the analyses are summarized below.

Both student groups exhibited continued learning throughout their three training fires. This finding indicates that manipulative skills and procedural knowledges associated with fire fighting training in the engine room simulator are not so simple and easily mastered that they constitute a trivial aspect of training and therefore can be ignored.

Instructor ratings of student performance during training tended to follow patterns set by objective measures of student performance. However, instructor ratings proved to be much less sensitive measures.

Throughout training, the group which extinguished WSS-treated fires exhibited less favorable performance. This finding, however, may have resulted from factors other the characteristics of the WSS-treated fire.

For the criterion test fires, neither the error data nor instructor ratings showed any practical differences in student performance, regardless of whether the students were trained on natural or WSS-treated fires. This finding indicates that, given sufficient amounts of training, the presence or absence of smoke in the training fires is of no consequence in terms of final student skill levels.

Questionnaire responses showed that both students and instructors generally favored enclosed structure training which would include some smoke-abated fires coupled with some natural fires. Students and instructors both cited advantages and disadvantages for each type of fire. Smoke was judged desirable because it adds realism. However, smoke-abated fires were judged to provide improved opportunities for students to learn and for instructors to observe and instruct. Advantages of smoke-abated fires were somewhat balanced by increased eye irritation and difficulty in breathing.

TRAINING FIRES

Each student received three training fires. Statistical comparisons of student performance and instructor ratings developed during the first and third training fires were completed to evaluate the relative performance of the two student groups.

Total errors made by all students in each of the two groups are shown in figure 1. Figure 2 shows a breakout of total errors committed during each of the three phases of engine room fire extinguishment. Both figures show that the group trained on the WSS-treated fires exhibited more errors. Figure 3 shows the percent of students in each group who exhibited error free performance throughout training and testing. A similar trend is apparent in that generally smaller percentages of students trained in WSS-treated fires exhibited error-free performance during the training. In all figures, training fires are numbered 1, 2 and 3. "N" is the natural test fire; "T" is the WSS-treated test fire.

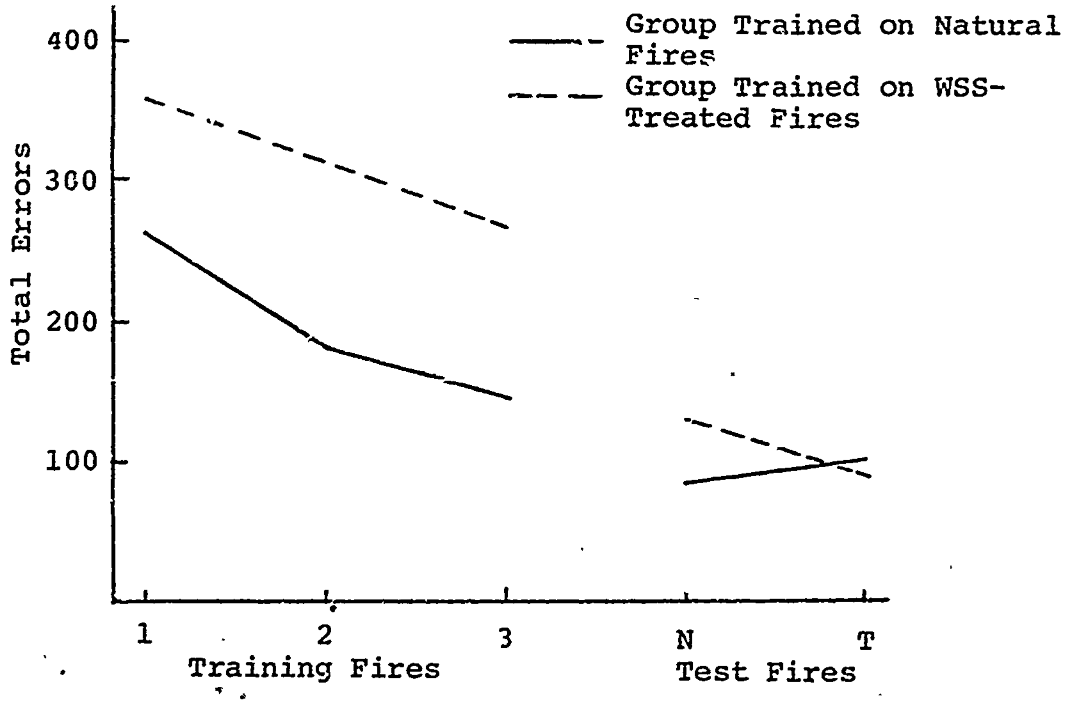

Figure 1. Total Student Errors, Training and Test Fires.

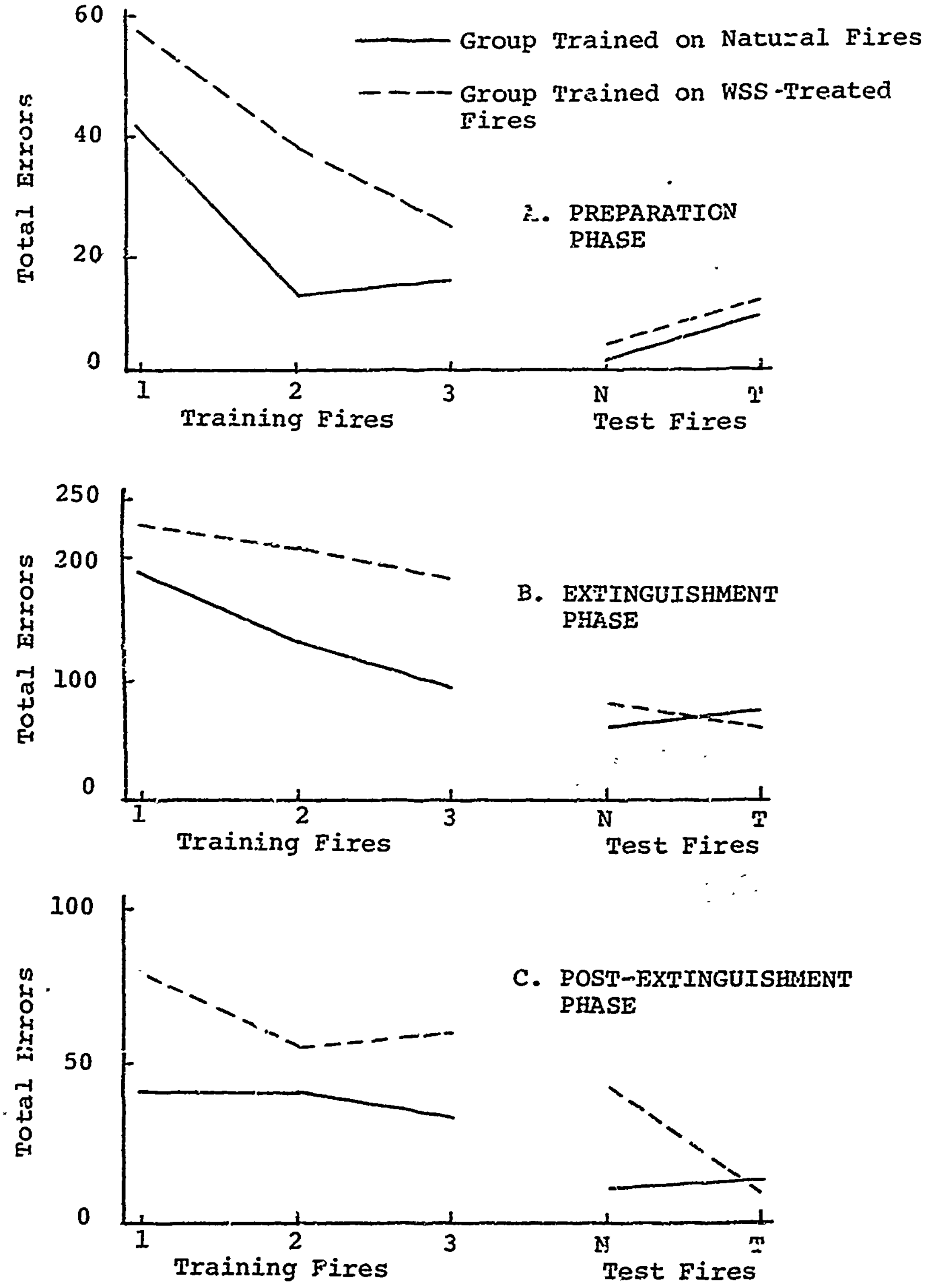

Figure 2. Subtotals of Student Errors, Each Phase of Training and Test Fires.

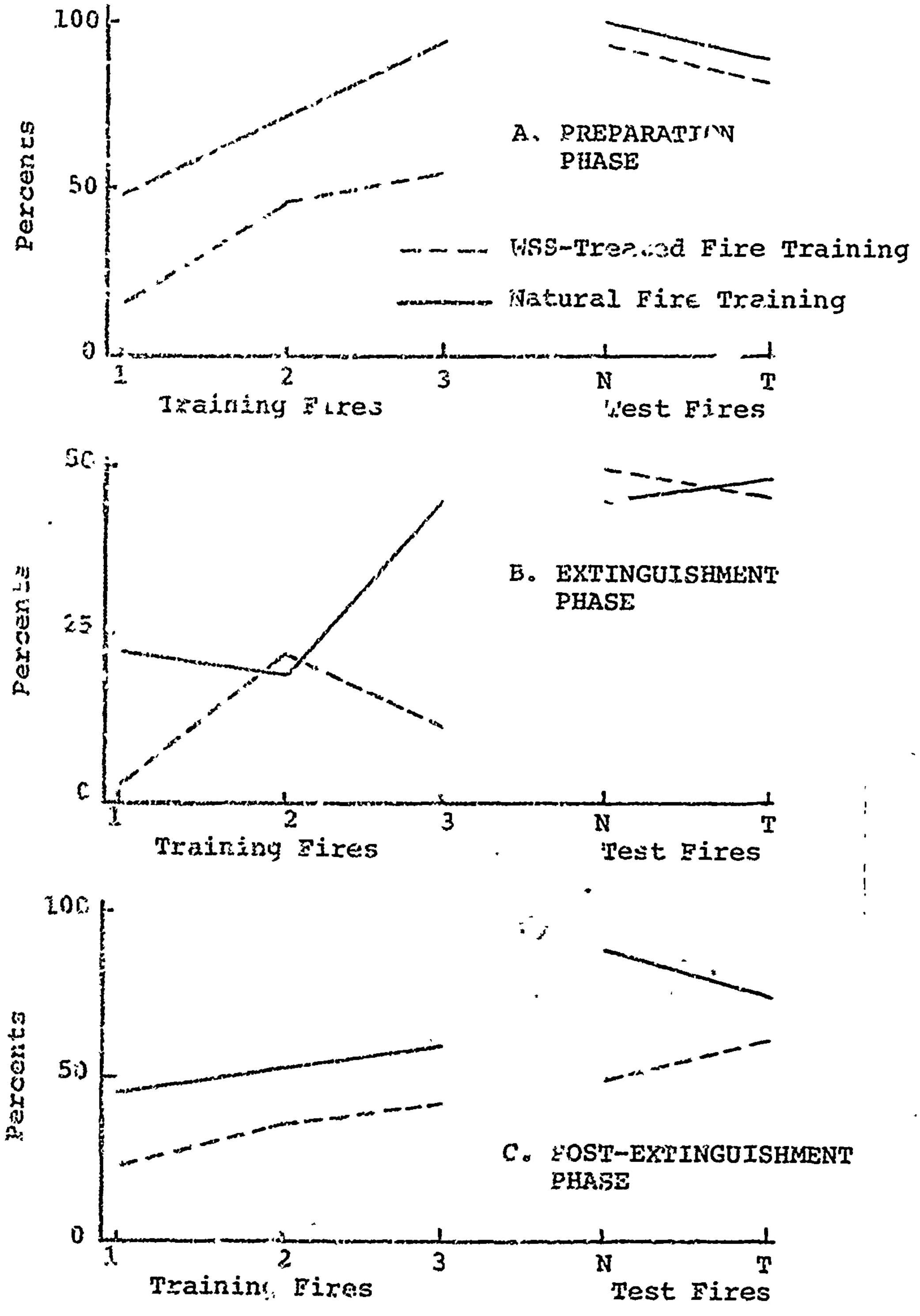

Figure 3. Percent of Students Exhibiting Error-Free Performance, Each Phase of Training and Test Fires.

Statistical comparisons of the average numbers of errors made by each group during the preparation phase of the first training fire showed that the group trained on the WSS-treated fires made significantly ($P = .05$)[1] more errors. A corresponding significant difference ($P = .01$) was found between the percentage of students in each group who exhibited error-free performance during the preparation phase of the first training fire. Statistical comparisons of the error data during the extinguishment phase showed no significant differences between the two groups. However, a significantly larger percentage of students trained on natural fires made error-free performance ($P = .01$). Comparisons between the two groups during the post-extinguishment phase revealed no statistically significant differences in performance.

Average ratings of student performance by instructors during each fire are shown in figure 4. Statistical tests showed that the instructors essentially rated the two groups the same during the first training fire.

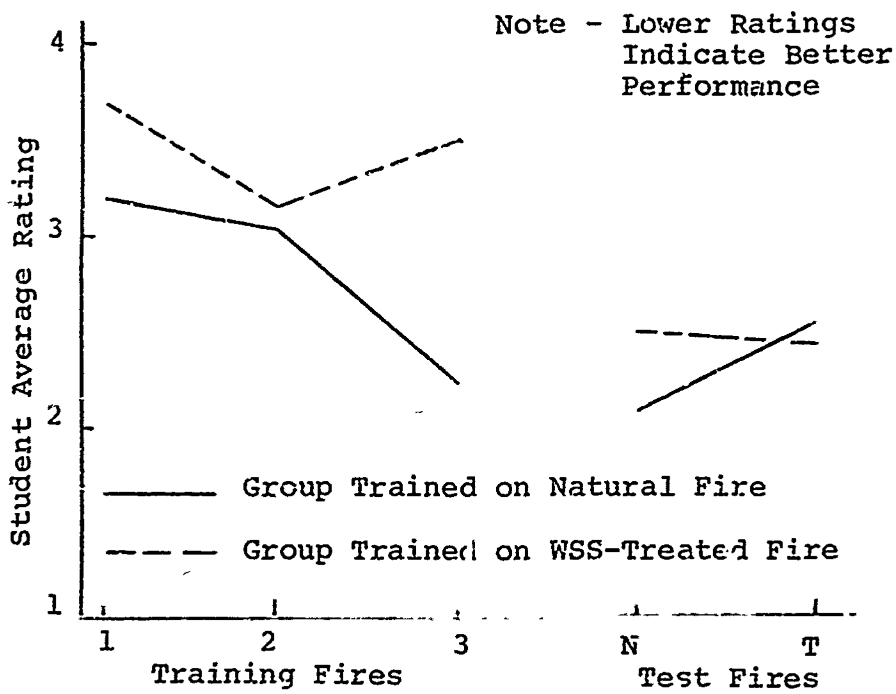

Figure 4. Instructor Ratings of Student Performance.

[1] Numbers in parentheses indicate the probability that differences between the two groups could have resulted from chance factors.

Similar tests were made of student performance and instructor ratings for the third training fire. Results of these tests were similar with results obtained from analyses of first fire data.

On the third fire, average numbers of errors made by students trained on WSS-treated fires were significantly greater during the preparation phase ($P = .05$), the extinguishment phase ($P = .01$) and the post-extinguishment phase ($P = .05$). The percentage of WSS-trained students who made errors was significantly greater during the preparation phase ($P = .01$) and the extinguishment phase ($P = .01$). The percentage data were essentially equivalent, however, during the post-extinguishment phase. Finally, analysis of instructor ratings showed that instructors rated the performance of the group trained on natural fires as significantly ($P = .01$) better during the third training fire.

Evidence of learning throughout training was tested by comparing the performance of each group on the first and third training fires. Both groups exhibited evidence that learning took place throughout the three training fires. Examination of figures 1 through 4 shows that, with the exception of instructor ratings, all measures of student performance showed about the same amount of improvement during training.

The following results were obtained for the group trained on WSS-treated fires. Comparisons of performance during preparation phases of the first and third training fires showed a significant ($P = .01$) decrease in the average number of student errors for the group trained on WSS-treated fires. Similarly, a significant ($P = .01$) increase in the percentage of students exhibiting error-free performance was established. Identical patterns were established for WSS-trained students during the extinguishment phase. No statistically reliable evidence of learning was found during analyses of post-extinguishment performance. Comparison of overall instructor ratings of student performance showed no reliable change throughout the training period for the group trained on WSS-treated fires.

Comparisons of performance measures for the group trained on natural fires produced similar, but not identical results. During the preparation phase a significant ($P = .05$) decrease in student errors between the first and third fires was identified. Similarly, a significant ($P = .01$) increase in the percentage of students exhibiting error-free performance during the preparation phase was established. During the extinguishment phase, a significant reduction ($P = .01$) in student errors was established, but the percentage of students exhibiting error-free performance did not change reliably. No statistically reliable evidence of learning was found during analyses of post-extinguishment performance. Comparison of overall instructor ratings of student

8. In which type of fire was it most difficult to breathe?

Natural	Treated	
30%	74%	Natural
40%	4%	Treated
30%	22%	Both about the same

9. Were the fumes in the natural fire so great that they reduced your ability to fight the fire?

Natural	Treated	
41%	52%	Yes
59%	48%	No

10. In the treated fire, were the fumes so great that they reduced your ability to fight the fire?

Natural	Treated	
59%	4%	Yes
41%	96%	No

11. Which type of fire felt hotter to you?

Natural	Treated	
70%	37%	Natural
8%	15%	Treated
22%	48%	Both about the same

12. Which type of fire is best for training fire fighting skills?

Natural	Treated	
22%	30%	Natural
33%	30%	Treated
45%	40%	Both about the same

13. After the fire had been beaten back to where it was underneath the two metal boxes, which fire was most difficult to extinguish?

Natural	Treated	
33%	22%	Natural
26%	30%	Treated
41%	48%	Both about the same

14. Overall, which type of fire was easiest to extinguish?

Natural	Treated	
22%	19%	Natural
48%	35%	Treated
30%	46%	Both about the same

performance showed a significant (P = .01) improvement in instructor estimates of student performance over the course of training.

Taken as a whole, results of the analyses cited above indicate that both groups of students exhibited learning throughout the three training fires. Examination of figures 1 through 4 indicates that learning may also have continued on into the first criterion test fire. Evidence of learning was most pronounced for preparation and extinguishment phases of training. Results of the analyses strongly indicate that manipulative skills and procedural knowledges associated with fire fighting training in the engine room simulator are not so simple and easily mastered that they constitute a trivial aspect of training and therefore can be ignored.

GROUP DIFFERENCES DURING TRAINING

On the surface, results of the analyses cited above could be interpreted as clearly indicating that, during training, students trained on WSS-treated fires performed poorer than students trained on natural fires. Several qualifying factors have direct bearing, however, on any such interpretation. Among the factors are possible fundamental differences between the two student groups, instructor evaluation opportunities and procedures, and, of course, inherent differences in the training characteristics of the two fires.

The two student groups were well matched in terms of the background experience information which was available. However, lack of time precluded any opportunity to match the two groups in terms of skills, knowledges or aptitudes directly relevant to fire fighting. It is possible, therefore, that the two student groups were somehow different in terms of their abilities to learn fire fighting tasks. This possibility was informally confirmed through conversations with the evaluation instructors, who felt that the students trained on the natural fires were fundamentally a better group of students. This possibility is generally supported by the fact that instructors rated the overall performance of the group trained on the natural fires significantly better.

Trends in the performance data also support the group difference hypothesis. During both the first and third training trials, the group trained on WSS-treated fires exhibited significantly greater average numbers of errors during the preparation phase. Additionally, lesser percentages of students in this group exhibited error-free performance during the preparation phase of training fires 1 and 3 and during the post-extinguishment phase of training fire 3. These findings are of interest because performance during these phases should be totally unaffected by whether the WSS system was operating or not.

This follows since actual extinguishment procedures were not involved in either the preparation or post-extinguishment phases. It is quite probable, therefore, that increased errors resulted because students trained on WSS-treated fires were not fundamentally as capable as the group trained on natural fires.

Additional support for the group difference hypothesis also is shown in figure 5, which presents the total number of instances in which students balked or hesitated during all three phases of all training and test fires. The figure shows that many more instances of hesitation were exhibited by students trained on the WSS-treated fire. One interpretation of this trend is that the group of students trained on WSS-treated fires was, as a whole, less capable. It also is possible that characteristics of the WSS-treated fires were responsible for the differences. This possibility is less likely, however, because both groups of students tended to rate the WSS-treated fire as less threatening and easier to extinguish. The possibility of inherent differences in the training characteristics of the two fires cannot be totally discounted, however.

WSS-treated fires provide for increased visibility in the simulator and improved opportunities for instructors to see student errors and hesitations. It is possible, therefore, that the evaluation instructors were able to "catch" more student errors in the WSS-treated fires, thus resulting in increases in the measured error rates for the group.

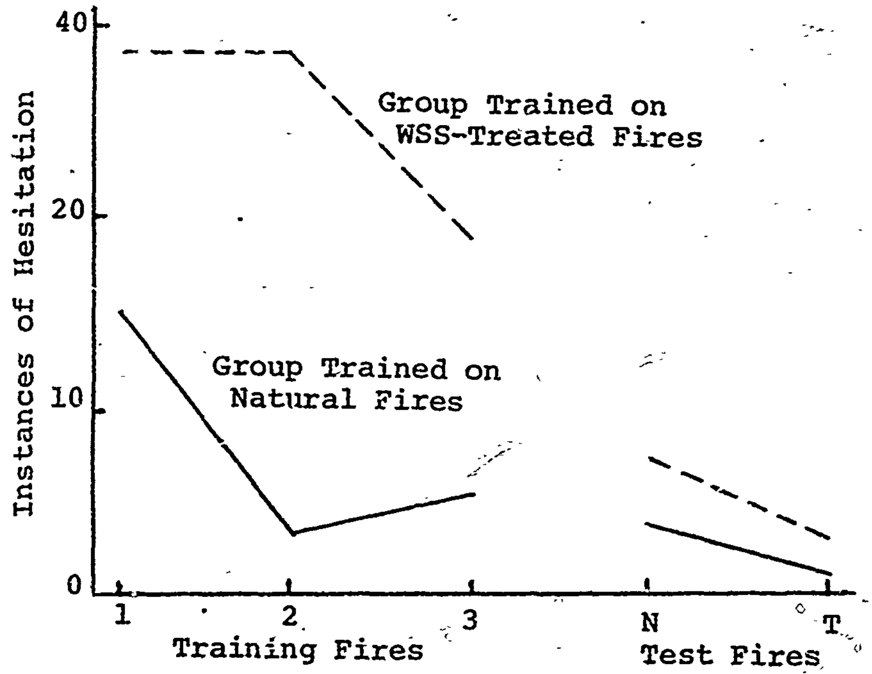

Figure 5. Instances of Student Hesitation Throughout Training and Test Fires.

A final factor of potential impact involves the sequence in which the two groups were trained and tested. The group which received the WSS-treated training fires was trained and tested during the first one-week period. It is possible that instructor sensitivity was greater during the first few days of the first week because of the novelty and uniqueness of the study and the performance evaluation procedures. This also could have resulted in increases in the measured error rates for the group trained on WSS-treated fires.

Finally, it can be seen that the slopes of the learning curves in figures 1 through 4 are quite similar, indicating that rates of learning were highly similar for both groups. This can be interpreted as a further indication that the training value of both types of fires is highly similar in terms of the building of fire fighting skills and knowledges.

Taken together, it is felt that the performance data do not necessarily indicate that natural engine room fires are superior to WSS-treated fires for building skills and knowledges. Further evidence for this reasoning is contained in results of analyses of criterion test fire performance data.

CRITERION TEST FIRES

Following their three training trials, each student group extinguished one WSS-treated and one natural criterion test fire. Analysis of performance data revealed only one minor difference between the two groups on either of the criterion test fires. Trends in student performance during the criterion test fires are shown in figures 1 through 5.

Transfer of training was assessed by comparing performance of each of the two student groups on both of the criterion test fires. Average numbers of student errors, percentages of students exhibiting error-free performance, and instructor ratings were analyzed statistically for preparation, extinguishment and post-extinguishment phases. No statistically significant differences were found, indicating that the transfer of training from each type of training fire to each type of criterion test fire was essentially the same.

Separate analyses were completed to contrast the performance of the two student groups on each criterion test fire. Again, average numbers of student errors, percentages of students exhibiting error-free performance, and instructor ratings were statistically analyzed. No statistically significant differences were found for either the preparation or extinguishment phase data. A significantly ($P = .05$) greater percentage of students trained on the WSS-treated fires made errors during the post-extinguishment phase of the natural test fires. No other differences were significant.

OPINION DATA

Opinion data are presented in two groupings: summaries of semantic differential rating scale trends, and summaries of questionnaire data trends. Each grouping is further subdivided into instructor responses and student responses.

SEMANTIC DIFFERENTIAL RATING SCALE TRENDS. Semantic differential rating scales were administered to students and instructors. The rating scales consisted of word-pairs comprised of descriptive terms and their opposites (e.g., good - bad). Each word pair was separated by a seven-point rating scale. Students and instructors placed X's along the rating scales to reflect the strength of their opinions regarding the training value of the fires. One semantic differential rating scale was completed to assess the natural fires; a second was completed to assess the WSS-treated fires. Further information regarding the semantic differential scales is presented in Appendix D.

Measures of central tendency of the ratings (medians) were computed. Where the median ratings of the two fires were different, statistical tests of the differences were completed. Where the statistical significance of the differences equalled or exceeded $P = .05$, the two values were independently reported. Where the level of the significance was less, a new consensus median was computed from the combined ratings of the two fires.

Trends in the rating scale data are best interpreted by comparing differences in which the same group rated each fire on each word-pair. Overall trends in strength of opinion also can be obtained by examining the actual value of each rating. For this type of examination, it is necessary to bear in mind that the central value (4) on the rating scale reflects a neutral opinion of the training value of the fires with respect to each word-pair. As median ratings depart from the central value, an increase in strength or degree of opinion is shown. The direction of the opinion is indicated by the word in each pair toward which the median value lies closest.

Figure 6 summarizes how Fire Fighting School instructors rated the two fires. For the most part, all ratings were on the positive side. Additionally, in 11 of the 16 comparisons the instructors rated the fires as equivalent. However, the data also indicate that the natural fires are more fatiguing, harder, more stressful and more risky than the WSS-treated fires. The natural fires were rated as more effective, although the WSS-treated fires also were rated as being effective for training.

Whereas instructor ratings are based upon more extensive experience with each type of fire as well as an instructor's viewpoint toward training value, student responses are based upon more limited experience with each type of fire coupled with a training recipient's viewpoint.

	1	2	3	4 Neutral	5	6	7	
Versatile				N/T				Limited
Assistance			N/T					Hinderance
Active			N/T					Passive
Valuable			N/T					Worthless
Flexible			N/T					Rigid
Manageable			N/T					Uncontrollable
Good		N/T						Bad
Favorable		N/T						Unfavorable
Helpful		N/T						Harmful
Acceptable			N/T					Unacceptable
Practical		N/T						Impractical
Restful					T	N		Fatiguing
Effective	N	T						Ineffective
Easy					T	N		Hard
Soothing					T	N		Stressful
Safe				T	N			Risky

Note: "N" shows the median rating of the natural fires.
"T" shows the median rating of the treated fires.

Figure 6. Trends in Instructor Ratings of Natural and WSS-Treated Fires.

Figure 7 summarizes how students trained on natural fires rated the two types of fires. The two fires were rated as equivalent in 5 of the 16 comparisons. Although a majority of all ratings of both fires was on the neutral to positive side, three ratings dealing with fatigue, stress and risk in the natural fire were on the negative side of the neutral rating column. Of the 11 comparisons in which the fires were not rated the same, the WSS-treated fire was rated more positively all 11 times.

Figure 8 summarizes how students trained on WSS-treated fires rated the two fires. The two fires were rated as equivalent in 7 of the 16 comparisons. Students trained on WSS-treated fires were more critical of the natural fires, as indicated by the fact that 6 median ratings of the natural fire were on the negative side of the neutral column. Additionally, in all but one comparison involving a significant difference, WSS-treated fires were rated more positively.

Where significant differences were found, the degree of difference (number of scale units separating pairs of ratings) was about the same for both student groups. In a relative sense, therefore, the two student groups rated differences between the two fire types as about the same. Overall, both student groups tended to rate the training value of WSS-treated fires more positively.

QUESTIONNAIRE DATA SUMMARY. Although different questionnaires were administered to students and instructors, some of the questions and topic areas addressed were the same in both questionniares. Where direct comparisons were possible, trends in questionnaire responses of instructors and students have been summarized together. Separate summaries are presented for topic areas which were different in the two questionnaires. Detailed responses to all questionnaire items are presented in Appendices B and C.

Students and instructors both indicated that fumes associated with the WSS-treated fires resulted in increased eye irritation and difficulty in breathing. WSS-treated fires also resulted in improved visibility, however. Students indicated that this condition provided a better opportunity to learn fire fighting tasks, and instructors indicated that it provided an improved opportunity to instruct and to observe student actions and reactions. Instructors indicated that eye irritation or breathing difficulty was great enough that it interfered with instructional capabilities, but students felt that learning opportunities were improved by WSS-treated fires. However, students indicated that the smoke associated with natural fires interfered with their ability to see the effects of their fire fighting efforts.

	1	2	3	4	5	6	7	
				Neutral				
Versatile				N/T				Limited
Assistance				N/T				Hinderance
Active			N/T					Passive
Valuable		T	N					Worthless
Flexible			T	N				Rigid
Manageable		T	N					Uncontrollable
Good		T		N				Bad
Favorable	T		N					Unfavorable
Helpful		T		N				Harmful
Acceptable		T		N				Unacceptable
Practical		T	N					Impractical
Restful				T		N		Fatiguing
Effective		N/T						Ineffective
Easy				N/T				Hard
Soothing				T		N		Stressful
Safe			T		N			Risky

Note: "N" shows the median rating of the natural fires.
"T" shows the median rating of the treated fires.

Figure 7. Trends in Student Ratings of Natural and WSS-Treated Fires, Students Trained on Natural Fires.

	1	2	3	Neutral 4	5	6	7	
Versatile				N/T				Limited
Assistance			N/T					Hinderance
Active		N	T					Passive
Valuable		N/T						Worthless
Flexible				N/T				Rigid
Manageable			T		N			Uncontrollable
Good		T		N				Bad
Favorable		T			N			Unfavorable
Helpful		T	N					Harmful
Acceptable			T	N				Unacceptable
Practical		T	N					Impractical
Restful					N/T			Fatiguing
Effective		N/T						Ineffective
Easy					T	N		Hard
Soothing						N/T		Stressful
Safe				T		N		Risky

Note: "N" shows the median rating of the natural fire.
"T" shows the median rating of the treated fire.

Figure 8. Trends in Student Ratings of Natural and WSS-Treated Fires, Students Trained on WSS-Treated Fires.

Instructors and students both indicated that the natural fires felt hotter. However, reliable temperature measurements were not available to validate this opinion.

When asked to indicate which type of fire was easier to extinguish, the students indicated the treated fire, while the instructors indicated the natural fire. Measurements of total times required to extinguish each fire favored the instructor response in that natural fires were extinguished somewhat more quickly.

Students were separately questioned in a number of areas dealing with confidence building. When asked which fire appeared most threatening when the simulator doors were first opened, student groups indicated the fires with which they had the most (training) experience. When asked which fire was best for building self confidence, a slight majority of both groups favored the WSS-treated fires. When asked how often they were afraid of being trapped by flames, a larger percentage of those trained on natural fires responded "often". When asked how often they wanted to run from the fires, somewhat greater percentages of students trained on natural fires indicated a tendency to want to run. Finally, instructors agreed that some training with smoke was necessary for confidence building.

Both groups of students unanimously favored fire fighting training which would include smoke-abated fires for skill development coupled with natural fires to show them generally what to expect if a shipboard fire broke out. This opinion is in agreement with other student and instructor opinions cited thus far.

Instructors were separately questioned in a number of training effectiveness areas dealing with both engine room applications and other applications of WSS-treated and natural fires.

A majority of instructors agreed that some form of smoke abatement was either desirable or necessary from an environmental standpoint. However, over half of the instructors were in favor of some form of smoke during fire fighting training because of the realism which smoke adds and because of the student confidence which is assumed to result from encountering smoke. Balancing comments included increased visibility, improved safety, and improved opportunities to observe and instruct students during WSS-treated fires.

For open area fires, instructors also indicated that natural fires were better for building a student's confidence. However, instructors were divided on which type of open fire presents the best opportunity to evaluate a student's performance. Similarly, instructors were divided on which type of engine room fire provides the best opportunity to evaluate students, with the

differences having been divided between improved visibility versus realism of the training environment.

When asked whether engine room fires were more effective with versus without smoke, a slight majority favored the natural fire (with smoke) alternative. When asked the same question regarding open fires, a slight majority selected WSS-treated fires.

Overall, Fire Fighting School instructors were in favor of fire fighting training which would include some smoke-abated fires coupled with natural fires for student skill and confidence building. This opinion appears to be in agreement with student opinions cited above.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Performance of students trained on either natural or WSS-treated fires in the engine room simulator indicated that continued learning of fire fighting procedural skills and knowledges continued throughout the three training fires. Assuming that student confidence building can best be accomplished when students are effectively able to handle the unique procedural requirements of a training situation, it is concluded that Fire Fighting School students would meaningfully benefit from up to three exposures to simulated engine room fires at the nozzleman position.

The rates at which students learned during either natural or WSS-treated training fires were highly comparable. This and other findings support the conclusion that natural and WSS-treated simulated engine room fires are effective for training fire fighting procedural skills and knowledges.

Students and instructors strongly favored providing simulated engine room fire fighting training which would include some exposure to smoke. Reasoning for their preferences centered around confidence building and included realism provided by smoke and the fact that shipboard fires are, by nature, smokey. It is concluded, therefore, that some simulated engine room training with smoke (e.g., natural fires) should be included in training.

RECOMMENDATIONS

Based upon results of the study, it is recommended that Fire Fighting School students receive up to three simulated engine room training fires in which they act as nozzleman. It is further recommended that the last training fire for each student in the engine room simulator should incorporate a smoke-filled environment.

It is further recommended that oxygen breathing apparatus should be used by both students and instructors, not only from a potential health hazard avoidance standpoint, but also from the standpoint of further equating WSS-treated and natural training fires. Additionally, a further element of realism would be added.

Finally, it is recommended that training effectiveness evaluations of other methods of smoke abatement should be investigated. Ideally, the methods and procedures of the present study should be repeated in any future evaluations.

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APPENDIX A

STUDENT PERFORMANCE CHECKLIST

PERFORMANCE CHECKLIST

Day ________ Date ________ Training ______ Criterion ________

Fire No. ____________ Type ________________

Student No. _________ Name ______________________________

Instructor No. ______ Name ______________________________

	Criticality of Error		
	Low	Med.	High
1. Test Water			
Was Inboard of Hose	____	____	____
Improper Nozzle Angle	____	____	____
Moved Bail Past Fog	____	____	____
Dropped Hose	____	____	____
Didn't Move Bail to Off	____	____	____
Didn't Assume Standby	____	____	____
Other ____________________	____	____	____
2. Standby Position			
Knuckles not Up	____	____	____
Aft Hand not on Bail	____	____	____
Other ____________________	____	____	____
3. Water On			
Improper Nozzle Angle	____	____	____
Moved Bail Past Fog	____	____	____
Balked	____	____	____
Not Move Aft Hand Back	____	____	____
Other ____________________	____	____	____
4. Cool Door			
Non-Circular Water Pattern	____	____	____
Water Pattern Too Low	____	____	____
Other ____________________	____	____	____

	Criticality of Error		
	Low	Med.	High
5. Instructor Opens Door			
Improper Hose Height	___	___	___
Water Pattern too Low	___	___	___
Other ________________	___	___	___
6. Step to Door			
Balked	___	___	___
Froze	___	___	___
Ran	___	___	___
Did not Step to Door	___	___	___
Tried to Step Through	___	___	___
Water Pattern too Low	___	___	___
Other ________________	___	___	___
7. Feed Hose Through Forward Hand			
Balked	___	___	___
Froze	___	___	___
Ran	___	___	___
Dropped Hose	___	___	___
Changed Bail from Fog	___	___	___
Put Foot through Doorway	___	___	___
Failed to Circle	___	___	___
Circle Size too Small	___	___	___
Other ________________	___	___	___

	Criticality of Error Low	Med.	High
8. Standby to Gooseneck/Gooseneck			
Balked	____	____	____
Froze	____	____	____
Ran	____	____	____
Knuckles not Up	____	____	____
Not Move Aft Hand to Coming	____	____	____
Forward Hand Improper Position	____	____	____
Changed Bail from Fog	____	____	____
Dropped Hose	____	____	____
Gooseneck Sweep too Narrow	____	____	____
Gooseneck Sweep Eratic	____	____	____
Put Foot through Doorway	____	____	____
Stuck Head in Before Told to	____	____	____
Stopped Goosenecking too Soon	____	____	____
Other ____________	____	____	____
9. Step in and Level Off			
Balked at Stepping in	____	____	____
Froze	____	____	____
Ran	____	____	____
Knuckles not Up	____	____	____
Not Squat Low Enough	____	____	____
Hose not Below Knees	____	____	____
Hose not Level	____	____	____
Dropped Hose	____	____	____
Inappropriate Change, Aft Hand Position	____	____	____
Balked, Advance to 1st Check Point	____	____	____
Sweep not Wide Enough	____	____	____
Sweep was Eratic	____	____	____

	Criticality of Error		
	Low	Med.	High
9. (continued...)			
Sweep not Directed at Fire	____	____	____
Digging Occurred	____	____	____
Other ____________________	____	____	____
Other ____________________	____	____	____
10. Let's Go Get It			
Balked, Advance to 2nd Check Point . . .	____	____	____
Froze	____	____	____
Ran	____	____	____
Knuckles not Up	____	____	____
Not Squat Low Enough	____	____	____
Hose not Below Knees	____	____	____
Hose not Level	____	____	____
Dropped Hose	____	____	____
Unappropriate Change, Aft Hand Position.	____	____	____
Sweep not Wide Enough	____	____	____
Sweep was Eratic	____	____	____
Sweep not Directed at Fire	____	____	____
Water Pattern too Low or High	____	____	____
Digging Occurred	____	____	____
Other ____________________	____	____	____
Other ____________________	____	____	____
10a. Starboard Door Only			
Not Lay Nozzle on Deck Grate	____	____	____
Water Pattern not Level	____	____	____
Pattern not Between Condensers	____	____	____
Moved Bail Past Fog	____	____	____
Took Hand Off Nozzle	____	____	____
Other ____________________	____	____	____

	Criticality of Error		
	Low	Med.	High
11. Water Off			
Not Use Aft Hand on Bail	____	____	____
Didn't Move Bail to Off	____	____	____
Dropped Nozzle	____	____	____
Didn't Re-position Aft Hand	____	____	____
Tried to Turn & Walk Out	____	____	____
Didn't Monitor for Flare-Ups	____	____	____
Dropped Hose	____	____	____
Knuckle Not Up	____	____	____
Turned Water On	____	____	____
Other ______________________	____	____	____
12. Back It To The Door			
Didn't Monitor for Flare-Ups	____	____	____
Tried to Turn & Walk Out	____	____	____
Dropped Hose	____	____	____
Knuckles not Up	____	____	____
Backed Out too Fast	____	____	____
Didn't Stop or Exit at Door Properly . .	____	____	____
Other ______________________	____	____	____

ADDITIONAL INFORMATION

A. Was your Backup Hose Needed to Help Fight the Fire? ____________

B. Please indicate your overall opinion of this student's performance by placing an "X" inside the appropriate box of the rating scale shown below.

Good			So-So			Bad
1	2	3	4	5	6	7

APPENDIX B

STUDENT QUESTIONNAIRE AND DATA SUMMARY

This appendix contains the questionnaire items which constituted the questionnaire administered to both groups of students at the conclusion of their training and testing. In the questionnaire, the items and response options shown in this appendix were randomly sequenced to minimize possible response biases. In this appendix, the items have been organized in relation to the topic areas which they address. Similarly, all response option sequences have been standardized.

The following instructions were printed at the top of each student questionnaire:

> The purpose of this study is to determine whether the use of a water spray system to reduce the amount of smoke has any impact on the training value of the fires. Results of the study are extremely important to the Navy. The opinions and judgements which you give in this questionnaire will be a significant part of the results of the study.
>
> Please read each question carefully. Then place an "X" by the answer which most closely represents your opinion or judgement. Select only one answer for each question. Please answer all questions.

Student reponses to each item have been converted to percentage values to facilitate the interpretation of trend information. Following each item, the percentage of students responding to each alternative answer are shown. Responses of the group trained on the natural fires always are shown in the left-hand column. Responses of the group trained on the WSS-treated fires always are shown in the right-hand column.

Each question, along with a summary of student responses, is presented below. When interpreting the data, it may be useful to bear in mind that each student's response is the equivalent of approximately 4 Percentage points.

1. If you were to receive additional training at the Fire Fighting School sometime in the future, which type of fire would you prefer to be trained on?

Natural	Treated	
0%	0%	Natural
0%	0%	Treated
0%	0%	It doesn't matter
100%	100%	A combination of both types

2. Which fire resulted in the greatest discomfort due to irritation of your eyes?

Natural	Treated	
33%	74%	Natural
41%	4%	Treated
26%	22%	Both about the same

3. In the natural fire, did you find that irritation to your eyes was so great that it reduced your ability to fight the fire?

Natural	Treated	
52%	63%	Yes
48%	37%	No

4. In the treated fire, was eye irritation so great that it reduced your ability to fight the fire?

Natural	Treated	
44%	12%	Yes
56%	88%	No

5. In which fire was it most difficult to see what you were doing?

Natural	Treated	
81%	85%	Natural
11%	0%	Treated
8%	15%	Both about the same

6. To what extent was your fire fighting ability effected by visibility in the natural fire?

Natural	Treated	
0%	11%	Considerably improved
8%	11%	Improved
21%	22%	Not effected
42%	41%	Degraded
29%	15%	Considerably degraded

7. To what extent was your fire fighting ability effected by visibility in the treated fire?

Natural	Treated	
9%	33%	Considerably improved
21%	37%	Improved
33%	15%	Not effected
25%	11%	Degraded
12%	4%	Considerably degraded

10. In the natural fire, was eye irritation so great that is made it difficult to instruct?

20% Yes
80% No

11. In the treated fire, were the fumes so great that they made it difficult to instruct?

73% Yes
27% No

12. Was the smoke in the natural fire so great that it made it difficult to instruct?

27% Yes
73% No

13. In which type of engine room fire could you best see what the student was doing?

15% Natural
77% Treated
8% Both about the same

14. In which type of fire is it most difficult to breath?

15% Natural
65% Treated
20% Both about the same

15. Which type of engine room fire is most fatiguing to instruct in?

31% Natural
50% Treated
19% Both about the same

16. In which type of engine room fire does your workload seem greatest?

42% Natural
46% Treated
12% Both about the same

Consensus of Written Responses - Instructors selecting the natural fire indicated that workload was increased due to limited visibility, difficulty in breathing, and intense smoke. Those indicating that the treated fire posed greater workloads cited irritation due to the fumes caused by evaporation of the fuel oil and gasoline. The fumes proved to be the root of every comment; in particular, eye irritation and difficulty in breathing were cited. Additionally, the increased chance of a flashback also was cited frequently.

15. Which type of fire do you feel is best for building a student's confidence in his ability to survive a fire?

Natural	Treated	
30%	33%	Natural
40%	52%	Treated
30%	15%	Both about the same

16. At the beginning of each fire when the door was first opened, which type of fire appeared most threatening?

Natural	Treated	
70%	59%	Natural
11%	8%	Treated
19%	33%	Both about the same

17. How often were you afraid of being trapped by flames in the natural fire?

Natural	Treated	
44%	48%	Never
30%	48%	Sometimes
26%	4%	Often

18. How often were you afraid of being trapped by the flames in the treated fire?

Natural	Treated	
48%	59%	Never
44%	33%	Sometimes
8%	8%	Often

19. How close were you to wanting to run from the natural fire?

Natural	Treated	
41%	52%	Never considered it
37%	30%	Might have run if others weren't involved
22%	18%	Had to fight down powerful urge to run

20. How close were you to wanting to run from the treated fire?

Natural	Treated	
48%	73%	Never considered it
33%	15%	Might have run if others weren't involved
19%	12%	Had to fight down powerful urge to run

21. How confident were you that the natural fire could be controlled without danger to yourself?

Natural	Treated	
11%	26%	Very certain
22%	19%	Certain
45%	44%	Skeptical
15%	7%	Doubtful
7%	4%	Very doubtful

22. How confident were you that the treated fire could be controlled without danger to yourself?

Natural	Treated	
22%	27%	Very certain
33%	23%	Certain
37%	38%	Skeptical
4%	8%	Doubtful
4%	4%	Very doubtful

23. Overall, which type of fire did you feel was most threatening to your personal safety?

Natural	Treated	
55%	42%	Natural
15%	19%	Treated
30%	39%	Both about the same

APPENDIX C
INSTRUCTOR QUESTIONNAIRE AND DATA SUMMARY

This appendix contains the items which constituted the questionnaire administered to both the evaluation instructors and assisting (hose handling) instructors from the Fire Fighting School. In the questionnaire, the items and response options shown in this appendix were randomly sequenced to minimize possible response biases. In the appendix, the items have been organized in relation to the topic areas which they address. Similarly, sequences for all response options have been standardized.

The following instructions were printed at the top of each instructor questionnaire:

> Please read each question carefully. Then place an "X" by the answer which most closely represents your opinion or judgement. Select only one answer for each question. Feel free to write in comments.

A total of 26 instructors completed questionnaires. Responses to each item involving a multiple response option were tabulated and converted to percentage values to facilitate the interpretation of trend information. On occasion, one or two instructors did not respond to a question. This factor was taken into account when computing percentage values.

Consensus statements of written responses were developed for all questions requiring or encouraging written responses. In this appendix, consensus statements immediately follow each question.

Several rating scales were used in the instructor questionnaire. The method for making ratings was identical with the method used for the semantic differential rating scales (Appendix D). The instructors were verbally informed of the parallel in method. In this appendix, the percent of instructors selecting each interval of each rating scale is shown, again to facilitate the interpretation of trend information.

Each question, along with a summary of instructor responses and, as appropriate, a consensus of written responses, is presented on the following pages. When interpreting the data, it may be useful to bear in mind that each instructor's response is the equivalent of approximately 4 percentage points.

1. From the standpoint of air pollution, what is your opinion on the need to get rid of smoke generated by training fires?

    46% Important
    38% Desirable
    16% Unnecessary

2. How do you feel about giving students most of their engine room training using treated fires, but also giving them experience fighting at least one natural engine room fire?

Favorable			Neutral			Unfavorable
54%	12%	14%	8%	--	8%	4%

3. How do you feel about giving students most of their open fire training using treated fires, but also giving experience fighting at least one natural open fire?

Favorable			Neutral			Unfavorable
38%	12%	12%	30%	4%	4%	--

4. Which type of engine room fire felt hotter to you?

50% Natural
35% Treated
15% Both about the same

5. Which type of engine room fire is most apt to flash back?

15% Natural
81% Treated
4% Both about the same

6. Which type of engine room fire is easiest to extinguish?

61% Natural
24% Treated
15% Both about the same

7. In which type of engine room fire is it easiest for you to instruct students in how to fight the fires?

31% Natural
46% Treated
23% Both about the same

8. In which type of engine room fire do you have to help the students most?

60% Natural
12% Treated
28% Both about the same

9. In the treated fire, was eye irritation so great that it made it difficult to instruct?

68% Yes
32% No

10. In the natural fire, was eye irritation so great that is made it difficult to instruct?

    20% Yes
    80% No

11. In the treated fire, were the fumes so great that they made it difficult to instruct?

    73% Yes
    27% No

12. Was the smoke in the natural fire so great that it made it difficult to instruct?

    27% Yes
    73% No

13. In which type of engine room fire could you best see what the student was doing?

    15% Natural
    77% Treated
    8% Both about the same

14. In which type of fire is it most difficult to breath?

    15% Natural
    65% Treated
    20% Both about the same

15. Which type of engine room fire is most fatiguing to instruct in?

    31% Natural
    50% Treated
    19% Both about the same

16. In which type of engine room fire does your workload seem greatest?

    42% Natural
    46% Treated
    12% Both about the same

Consensus of Written Responses - Instructors selecting the natural fire indicated that workload was increased due to limited visibility, difficulty in breathing, and intense smoke. Those indicating that the treated fire posed greater workloads cited irritation due to the fumes caused by evaporation of the fuel oil and gasoline. The fumes proved to be the root of every comment; in particular, eye irritation and difficulty in breathing were cited. Additionally, the increased chance of a flashback also was cited frequently.

17. What are some of the benefits of having smoke with the engine room fires?

    Consensus of Written Responses - Realism provided by smoke was identified as the most important benefit.

18. What are some of the benefits of not having smoke with the engine room fires?

    Consensus of Written Responses - Typically cited benefits included increased visibility, improved safety, and a better opportunity for students to see the effects of their fire fighting actions.

19. Which type of engine room fire do you feel is best for training fire fighting skills?

    50% Natural
    15% Treated
    20% Both types together
    15% Either type

20. Which type of open fire do you feel is best for training fire fighting skills?

    39% Natural
    19% Treated
    23% Both types together
    19% Either type

21. Which type of open fire do you feel is best for building a student's confidence in his ability to survive a fire?

    62% Natural
    8% Treated
    30% Both about the same

22. Which type of engine room fire do you feel is best for building a student's confidence in his ability to survive a fire?

    81% Natural
    4% Treated
    15% Both about the same

    Consensus of Written Responses - A natural fire is more closely related to what the student will encounter in an actual engine room fire. Some concern was expressed that the absense of smoke in training fires would not sufficiently prepare the student to cope with a smoke-filled fire situation. Those selecting the treated fire cited a better opportunity for students to see the effects of their fire fighting actions, thus enhancing their confidence in their ability to overcome fires.

23. Which type of open fire provides the best opportunity to evaluate students?

31%	Natural
23%	Treated
46%	Both about the same

Consensus of Written Responses - Those selecting the natural fire cited realism of the evaluation setting as most important. Those selecting the treated fire cited improved visibility as as enhancement to the evaluation process.

24. Which type of engine room fire provides the best opportunity to evaluate students?

40%	Natural
44%	Treated
16%	Both about the same

Consensus of Written Responses - Instructors selecting the natural fire cited fire realism and the attendant opportunity for instructors to evaluate how a student might deal with a real fire. Those selecting the treated fire cited improved visibility and the resulting improvement in the instructor's ability to clearly see the student's actions and reactions.

25. What is your overall opinion of the water spray system as a means of smoke abatement for engine room fires?

Good			Neutral				Bad
	42%	23%	12%	15%	4%	--	4%

26. What is your overall opinion of the water spray system as a means of smoke abatement for open fires?

Good			Neutral				Bad
	42%	23%	8%	23%	4%	--	--

27. What is your overall estimate of the quality of training which can be given in the engine room using the natural fire?

Effective			Neutral				Ineffective
	54%	27%	11%	4%	4%	--	--

28. What is your overall estimate of the quality of training which can be given in the engine room using the treated fire?

Effective			Neutral				Ineffective
	23%	19%	23%	8%	15%	8%	4%

APPENDIX D

SEMANTIC DIFFERENTIAL RATING SCALE AND INSTRUCTIONS

The following instructions were read to students and instructors before they completed the semantic differential rating scales. One rating scale sheet was distributed to each individual. An example of the rating scale is shown on the last page of this Appendix.

WSS-TREATED FIRE RATING

The purpose of this study is to determine whether the use of a water-spray system to reduce the amount of smoke has any impact on the training value of the fires. This study is very important to the Navy. Your opinions and judgements will be a significant part of the study.

You have been given a list of word-pairs. We would like you to rate the water-treated fire being investigated in this study by using the word-pairs.

Each word-pair consists of a descriptive word and its opposite. (e.g., good - bad) Each word pair is separated by a rating scale. Your task is to place an X in the column of the scale which most closely reflects your feeling about the water-treated fire in relation to each word-pair.

BLACKBOARD EXAMPLE

				Neutral				
	3	2	1	0	1	2	3	
Good	X							Bad
Soft				X				Hard
Slow					X			Fast

Here's an example of how the rating technique works. Assume that you're rating a girl whom you've just met, and that you're going to use the word-pairs shown on the board. If you feel that the "girl" implies something very good, you would place an "X" in column 3 as I have done in the example. On the other hand, if you feel that the "girl" implies something very bad, then the "X" should be placed in column 3 over here. If your feeling is neutral (i.e., your feeling about the girl implies neither good nor bad), then the "X" should be placed in column 0 -- neutral feeling.

After completing the rating of the girl using the first word-pair, she should be rated on the next word-pair (soft - hard). The same general instructions apply. If you feel that the "girl" implies softness, you would place an "X" in column 1, 2 or 3, depending upon the strength of your feeling. If you have no particular feeling about her in the soft - hard dimension, an "X" should be placed in column 0. If you feel that the girl implies hardness, you would place an "X" in column 1, 2 or 3 over here, depending upon the strength of your feeling.

The strength of your opinion, therefore, is relfected in the columns which you select for the ratings. Strongest responses are associated with the end columns. Strength of response gradually decreases until column 0 is reached, which reflects neutrality. This rule holds for all word-pairs.

In the example on the board, the last word-pair (slow - fast) may not particularly describe the "girl". A rating should still be attempted on the slow - fast dimension, however. In the rating scale which you have been given, you may also find word-pairs which don't appear to readily describe the water-treated fire. Please rate the fire using all word-pairs, even if some do not appear too appropriate. Rate the fire with respect to its training value.

Do not hesitate to use the extreme categories at each end of the scale. Use only one column for each word-pair. Always place your "X" squarely within a category as I have done in the example; do not place "X's" on the lines separating the categories as there are no midway ratings such as 2½. Once you have selected a column, do not change it.

If you have any questions, I will gladly answer them. If not, please complete the rating scale based on your initial feelings about the water-treated fire and its training value.

NATURAL FIRE RATING

After WSS-treated fire rating scales had been completed, they were collected and a second rating scale was distributed to each individual. The following instructions were then read.

Now we would like you to rate the natural fire with respect to its training value. Please rate the natural fire using all word-pairs, even if some do not appear too appropriate. Please complete the rating scale based on your initial feelings about the natural fire and its training value.

	Neutral							
	3	2	1	0	1	2	3	
Restful								Fatiguing
Uncontrollable								Manageable
Ineffective								Effective
Unfavorable								Favorable
Good								Bad
Flexible								Awkward
Helpful								Harmful
Acceptable								Unacceptable
Hinderance								Assistance
Worthless								Valuable
Easy								Hard
Soothing								Stressful
Versatile								Limited
Passive								Active
Effective								Ineffective
Safe								Risky
Practical								Impractical

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